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【Title of Invention】 LIQUID CRYSTAL DISPLAY HAVING HIGH-SPEED OF RESPONSE AND DRIVING METHOD THEREOF

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【List of Document Presented】
【Document Name】 Specification 1
【Document Name】 Drawings 1
【Document Name】 Abstract 1

【Document Name】 Specification

【Title of the Invention】 LIQUID CRYSTAL DISPLAY HAVING HIGH-SPEED OF RESPONSE AND DRIVING METHOD THEREOF

【Claims】

【Claim 1】

A color active matrix type vertically aligned mode liquid crystal display comprising on a substrate:

a scan signal wiring;

a video signal wiring;

a thin film transistor which is formed at an intersection of the scan signal wiring and the video signal wiring;

a transparent pixel electrode connected to the thin film transistor in which two or more long and slender slits are formed;

an active matrix substrate having a liquid crystal alignment direction control electrode in a lower layer of the slits of the transparent pixel electrode currently formed via an insulator film;

a color filter substrate facing the active matrix substrate; and

an anisotropic liquid crystal layer having a negative dielectric constant sandwiched by the active matrix substrate and the color filter substrate,

wherein in order to impress a voltage to liquid crystal molecules vertically aligned between the active matrix substrate and the color filter substrate, and to make the liquid crystal molecules tilt in different two directions or four directions, two kinds of following electrode structures are formed in one pixel of the active matrix substrate:

i) an electrode structure in which a transparent flat electrode is used in the color filter substrate side, and for the transparent pixel electrodes facing the transparent flat electrode in the active matrix substrate side, patterns (no transparent electrode in a slit part) having a shape of a long and slender slit are formed;

ii) an electrode structure in which a transparent flat electrode is used in the color filter substrate side, and for the transparent pixel electrode facing the transparent flat electrode in the active matrix substrate side, patterns having a shape of a long and slender slit are formed, and a liquid crystal alignment direction control electrode having almost the same shape as a shape of the slits and a larger dimension

than a dimension of the slits is formed in a lower layer of the slits via the insulator film.

【Claim 2】

A method for driving the vertically aligned mode liquid crystal display according to Claim 1,and a vertically aligned mode liquid crystal display being driven by the method,

wherein when a potential of the transparent pixel electrode separated for every pixel on the active matrix substrate side is lower than a potential of the facing flat common electrode on the color filter substrate side, a potential of the liquid crystal alignment direction control electrode currently placed in a lower layer of the slit of the transparent pixel electrode is set lower than a potential of the transparent pixel electrode;

when a potential of the transparent pixel electrode is higher than a potential of the facing flat common electrode of the color filter substrate side, a potential of the liquid crystal alignment direction control electrode placed in a lower layer of the slit of the transparent pixel electrode is set higher than a potential of the transparent pixel electrode; and

polarities of the potential of the transparent pixel electrode, and the potential of the liquid crystal alignment direction control electrode are reversed to a polarity of a potential of the common electrode in the color filter substrate side every vertical scanning period.

【Claim 3】

A color active matrix type vertically aligned mode liquid crystal display comprising on a substrate:

a scan signal wiring;

a video signal wiring;

a thin film transistor which is formed at an intersection of the scan signal wiring and the video signal wiring;

a transparent pixel electrode connected to the thin film transistor in which two or more long and slender slits are formed;

an active matrix substrate having a liquid crystal alignment direction control electrode in a lower layer of slits of the transparent pixel electrode currently formed via an insulator film;

a color filter substrate facing the active matrix substrate; and

an anisotropic liquid crystal layer having a negative dielectric constant sandwiched by the active matrix substrate and the color filter substrate,

wherein in order to impress a voltage to liquid crystal molecules vertically aligned between the active matrix substrate and the color filter substrate, and to make the liquid crystal molecules tilt in different two directions or four directions, two kinds of following electrode structures are formed in one pixel of the active matrix substrate:

i) an electrode structure in which a transparent flat electrode is used in the color filter substrate side, and for the transparent pixel electrodes facing the transparent flat electrode in the active matrix substrate side, patterns (no transparent electrode in a slit part) having a shape of a long and slender slit are formed;

ii) an electrode structure in which a transparent flat electrode is used in the color filter substrate side, and for the transparent pixel electrode facing the transparent flat electrode in the active matrix substrate side, patterns having a shape of a long and slender slit are formed, and two rows of liquid crystal alignment direction control electrodes that are mutually separated and set as potentials different from each other exist in a lower layer of the transparent pixel electrode via the insulated film, either of the liquid crystal alignment direction control electrodes has almost the same shape as a shape of a pattern of the shape of long and slender slits, and a larger dimension than a dimension of the slits, and two rows of the liquid crystal alignment direction control electrodes mutually separated are arranged in a direction of a scan signal wiring in a lower layer of the long and slender slits that are formed, mutually exchanged in an every fixed pixel cycle, in the transparent pixel electrode.

【Claim 4】

A method for driving the vertically aligned mode liquid crystal display according to Claim 3, and a vertically aligned mode liquid crystal display being driven by the method,

wherein when a potential of the transparent pixel electrode separated for every pixel of the active matrix substrate side is lower than a potential of the facing flat common electrode on the color filter substrate side, a potential of the liquid crystal alignment direction control electrode currently placed in a lower layer of the slit of the

transparent pixel electrode is set lower than a potential of the transparent pixel electrode;

when a potential of the transparent pixel electrode is higher than a potential of the facing flat common electrode of the color filter substrate side, a potential of the liquid crystal alignment direction control electrode placed in a lower layer of the slit of the transparent pixel electrode is set higher than a potential of the transparent pixel electrode;

potentials of the liquid crystal alignment direction control electrodes arranged in the vicinity of both sides of the scan signal wiring are set as polar potentials different from each other; and

polarities of the potential of the transparent pixel electrode, and each of the potentials of the two rows of the liquid crystal alignment direction control electrodes mutually separated in one pixel are reversed to a polarity of a potential of the common electrode on the color filter substrate side every vertical scanning period.

【Claim 5】

A color active matrix type vertically aligned mode liquid crystal display comprising on a substrate:

a scan signal wiring;

a video signal wiring;

a thin film transistor which is formed at an intersection of the scan signal wiring and the video signal wiring;

a transparent pixel electrode connected to the thin film transistor in which two or more long and slender slits are formed;

an active matrix substrate having a liquid crystal alignment control electrode in a lower layer of slits of the transparent pixel electrode currently formed via an insulator film;

a color filter substrate facing the active matrix substrate; and

an anisotropic liquid crystal layer having a negative dielectric constant sandwiched by the active matrix substrate and the color filter substrate,

wherein adjacent transparent pixel electrodes in a direction of the scan signal wiring are connected to a thin film transistor controlled by mutually different scan signal wirings,

further wherein, in order to impress a voltage to liquid

crystal molecules vertically aligned between the active matrix substrate and the color filter substrate, and to make the liquid crystal molecules tilt in different two directions or four directions, two kinds of following electrode structures are formed in one pixel of the active matrix substrate:

i) an electrode structure in which a transparent flat electrode is used in the color filter substrate side, and for the transparent pixel electrodes facing the transparent flat electrode in the active matrix substrate side, patterns (no transparent electrode in a slit part) having a shape of a long and slender slit are formed;

ii) an electrode structure in which a transparent flat electrode is used in the color filter substrate side, and for the transparent pixel electrode facing the transparent flat common electrode in the active matrix substrate side, patterns having a shape of a long and slender slit are formed, and a liquid crystal alignment direction control electrode having almost the same shape as a shape of the slit, and a larger dimension than a dimension of the slit is formed in a lower layer of the slit via the insulated film.

【Claim 6】

A method for driving the vertically aligned mode liquid crystal display according to Claim 5,and a vertically aligned mode liquid crystal display being driven by the method,

wherein when a potential of the transparent pixel electrode separated for every pixel on the active matrix substrate side is lower than a potential of the facing flat common electrode on the color filter substrate side, a potential of the liquid crystal alignment direction control electrode currently placed in a lower layer of the slit of the transparent pixel electrode is set lower than a potential of the transparent pixel electrode;

when a potential of the transparent pixel electrode is higher than a potential of the facing flat common electrode of the color filter substrate side, a potential of the liquid crystal alignment direction control electrode placed in a lower layer of the slit of the transparent pixel electrode is set higher than a potential of the transparent pixel electrode; and

polarities of the potential of the transparent pixel electrode, and the potential of the liquid crystal alignment direction control electrode are reversed to a polarity of the

potential of the common electrode in the color filter substrate side every vertical scanning period.

【Claim 7】

A color active matrix type vertically aligned mode liquid crystal display comprising on a substrate:

a scan signal wiring;

a video signal wiring;

a thin film transistor which is formed at an intersection of the scan signal wiring and the video signal wiring;

a transparent pixel electrode, connected to the thin film transistor, that has two or more of circular or polygonal holes and two or more long and slender slits currently formed therein;

an active matrix substrate having a liquid crystal alignment direction control electrode in a lower layer of the slits of the transparent pixel electrode currently formed via an insulator film;

a color filter substrate facing the active matrix substrate; and

an anisotropic liquid crystal layer having a negative dielectric constant sandwiched by the active matrix substrate and the color filter substrate,

wherein, in order to impress a voltage to liquid crystal molecules that are vertically aligned between the active matrix substrate and the color filter substrate and to make the liquid crystal molecules tilt in many directions, two kinds of following electrode structures are formed in one pixel of the active matrix substrate:

i) an electrode structure in which a transparent flat electrode is used on the color filter substrate side, and for transparent pixel electrodes facing thereto in the active matrix substrate side, circular or polygonal holes (no transparent electrodes in a portion of a hole) are formed;

ii) an electrode structure in which a transparent flat electrode is used in the color filter substrate side, and for transparent pixel electrodes facing the transparent flat electrode in the active matrix substrate side, patterns having a shape of a long and slender slit are formed, and a liquid crystal alignment direction control electrodes having almost the same shape as a shape of the slit, and a larger dimension than a dimension of the slit is formed in a lower layer of the slit via an insulated film.

【Claim 8】

A method for driving the vertically aligned mode liquid crystal display according to Claim 7,and a vertically aligned mode liquid crystal display being driven by the method,

wherein when a potential of the transparent pixel electrode separated for every pixel of the active matrix substrate side is lower than a potential of the facing flat common electrode on the color filter substrate side, a potential of the liquid crystal alignment direction control electrode currently placed in a lower layer of the slit of the transparent pixel electrode is set lower than a potential of the transparent pixel electrode;

when a potential of the transparent pixel electrode is higher than a potential of the facing flat common electrode of the color filter substrate side, a potential of the liquid crystal alignment direction control electrode placed in a lower layer of the slit of the transparent pixel electrode is set higher than a potential of the transparent pixel electrode; and

polarities of the potential of the transparent pixel electrode, and the potential of the liquid crystal alignment direction control electrode are reversed to a polarity of a potential of the common electrode in the color filter substrate side every vertical scanning period.

【Claim 9】

A color active matrix type vertically aligned mode liquid crystal display comprising on a substrate:

a scan signal wiring;

a video signal wiring;

a thin film transistor which is formed at an intersection of the scan signal wiring and the video signal wiring;

a transparent pixel electrode, connected to the thin film transistor, that has two or more of circular or polygonal holes and two or more long and slender slits currently formed therein;

an active matrix substrate having a liquid crystal alignment direction control electrode in a lower layer of the slits of the transparent pixel electrode currently formed via an insulator film;

a color filter substrate facing the active matrix substrate; and

an anisotropic liquid crystal layer having negative

dielectric constant sandwiched by the active matrix substrate and the color filter substrate,

wherein, in order to impress a voltage to liquid crystal molecules that are vertically aligned between the active matrix substrate and the color filter substrate and to make the liquid crystal molecules tilt in many directions, two kinds of following electrode structures are formed in one pixel of the active matrix substrate:

i) an electrode structure in which a transparent flat electrode is used in the color filter substrate side, and for the transparent pixel electrodes facing thereto in the active matrix substrate side, circular or polygonal holes (no transparent electrodes in a portion of a hole) are formed;

ii) an electrode structure in which a transparent flat electrode is used on a color filter substrate side, and for transparent pixel electrodes facing thereto in the active matrix substrate side, patterns having a shape of a long and slender slit are formed, and two rows of liquid crystal alignment direction control electrodes that are mutually separated and set as potentials different from each other exist in a lower layer of the transparent pixel electrode via the insulated layer, either of the liquid crystal alignment direction control electrodes have almost the same shape as a shape of a pattern of the shape of long and slender slits, and a larger dimension than a dimension of the slit; and

two rows of the liquid crystal alignment direction control electrodes mutually separated are arranged in a direction of a scan signal wiring in a lower layer of the long and slender slits that are formed, mutually exchanged in an every fixed pixel cycle, in the transparent pixel electrode.

【Claim 10】

A method for driving the vertically aligned mode liquid crystal display according to Claim 9,and a vertically aligned mode liquid crystal display being driven by the method,

wherein when a potential of the transparent pixel electrode separated for every pixel of the active matrix substrate side is lower than a potential of the facing flat common electrode on the color filter substrate side, a potential of the liquid crystal alignment direction control electrode currently placed in a lower layer of the slit of the transparent pixel electrode is set lower than a potential of the transparent pixel electrode;

when a potential of the transparent pixel electrode is higher than a potential of the facing flat common electrode on the color filter substrate side, a potential of the liquid crystal alignment direction control electrode placed in a lower layer of the slit of the transparent pixel electrode is set higher than a potential of the transparent pixel electrode; and

potentials of the liquid crystal alignment direction control electrodes arranged in the vicinity of both sides of the scan signal wiring are set as polar potentials different from each other; and polarities of the potential of the transparent pixel electrode, and each of the potential of the two rows of the liquid crystal alignment direction control electrodes mutually separated in one pixel are reversed to a polarity of a potential of the common electrode in the color filter substrate side every vertical scanning period.

【Claim 11】

A color active matrix type vertically aligned mode liquid crystal display comprising on a substrate:

a scan signal wiring;

a video signal wiring;

a thin film transistor which is formed at an intersection of the scan signal wiring and the video signal wiring;

a transparent pixel electrode, connected to the thin film transistor, that has two or more of circular or polygonal holes and two or more long and slender slits currently formed therein;

an active matrix substrate having a liquid crystal alignment direction control electrode in a lower layer of slits of the transparent pixel electrode currently formed via an insulator film;

a color filter substrate facing the active matrix substrate; and

an anisotropic liquid crystal layer having negative dielectric constant sandwiched by the active matrix substrate and the color filter substrate,

wherein adjacent transparent pixel electrodes in a direction of the scan signal wiring are connected to a thin film transistor controlled by mutually different scan signal wirings,

further wherein, in order to impress a voltage to liquid crystal molecules that are vertically aligned between the

active matrix substrate and the color filter substrate and to make the liquid crystal molecules tilt in many directions, two kinds of following electrode structures are formed in one pixel of the active matrix substrate:

i) an electrode structure in which a transparent flat electrode is used in the color filter substrate side, and for the transparent pixel electrodes facing thereto in the active matrix substrate side, circular or polygonal holes (no transparent electrodes in a portion of a hole) are formed;

ii) an electrode structure in which a transparent flat electrode is used in the color filter substrate side, and for the transparent pixel electrodes facing thereto in the active matrix substrate side, patterns having a shape of a long and slender slit are formed, and liquid crystal alignment direction control electrodes having almost the same shape as a shape of the slit, and a larger dimension than a dimension of the slit are formed in a lower layer of the slit via the insulated film.

【Claim 12】

A method for driving the vertically aligned mode liquid crystal display according to Claim 11,and a vertically aligned mode liquid crystal display being driven by the method,

wherein when a potential of the transparent pixel electrode separated for every pixel of the active matrix substrate side is lower than a potential of the facing flat common electrode on the color filter substrate side, a potential of the liquid crystal alignment direction control electrode currently placed in a lower layer of the slit of the transparent pixel electrode is set lower than a potential of the transparent pixel electrode;

when a potential of the transparent pixel electrode is higher than a potential of the facing flat common electrode of the color filter substrate side, a potential of the liquid crystal alignment direction control electrode placed in a lower layer of the slit of the transparent pixel electrode is set higher than a potential of the transparent pixel electrode; and

polarities of the potential of the transparent pixel electrode, and the potential of the liquid crystal alignment direction control electrode are reversed to a potential of the common electrode on the color filter substrate side every vertical scanning period.

【Claim 13】

The vertically aligned mode liquid crystal display according to Claim 1, 3, 5,

wherein a slit formed in the transparent pixel electrode on the active matrix substrate side and extending long and slender, and a slit forming a group with the liquid crystal alignment direction control electrode are arranged alternately, maintaining an almost parallel relationship in a direction making about ± 45 degrees to a direction of a scan signal wiring.

【Claim 14】

The vertically aligned mode liquid crystal display according to Claim 1, 3,5,

wherein there is adopted a structure that slits formed in the transparent pixel electrode in the active matrix substrate side and extending long and slender are arranged in a direction making ± 45 degrees to a direction of a scan signal wiring;

slits forming a group with the liquid crystal alignment direction control electrode are arranged in a parallel direction and in a perpendicular direction to a direction of the scan signal wiring; and

the liquid crystal alignment direction control electrode encloses a periphery of the pixel electrode while overlapping with the pixel electrode via the insulated film.

【Claim 15】

The vertically aligned mode liquid crystal display according to Claim 1, 3, 5,

wherein there is adopted a structure that a slit formed in a transparent pixel electrode in an active matrix substrate side and extending long and slender is arranged in a parallel direction and in a perpendicular direction to a scan signal wiring direction;

a slit forming a group with the liquid crystal alignment direction control electrode is arranged in parallel to the scan signal wiring direction; and

the liquid crystal alignment direction control electrode encloses a periphery of the pixel electrode while overlapping with the pixel electrode via the insulated film.

【Claim 16】

The vertically aligned mode liquid crystal display according to Claim 1, 3, 5,

wherein there is adopted a structure that slits formed in

the transparent pixel electrode in the active matrix substrate side and extending long and slender are arranged in a parallel direction and in a perpendicular direction to a scan signal wiring direction; and

slits forming a group with a liquid crystal alignment direction control electrode are arranged in a direction making ± 45 degrees to a direction of a scan signal wiring.

【Claim 17】

The vertically aligned mode liquid crystal display according to Claim 7, 9, 11,

wherein there is adopted a structure that slits forming a group with the liquid crystal alignment direction control electrode are arranged in a parallel direction and in a perpendicular direction to a direction of the scan signal wiring so as to enclose two or more of circular or polygonal holes currently formed in the transparent pixel electrode in the active matrix substrate side; and

the liquid crystal alignment direction control electrode encloses a periphery of the pixel electrode while overlapping with the pixel electrode via the insulated film.

【Claim 18】

The vertically aligned mode liquid crystal display according to Claim 1, 3,5,7,9, 11,

wherein the liquid crystal alignment direction control electrode formed in a lower layer of slits of the transparent pixel electrode via the insulated layer is simultaneously formed in the same layer at the time of formation of the scan signal wiring.

【Claim 19】

The vertically aligned mode liquid crystal display according to Claim 1, 3,5,7,11,

wherein additional capacitance is formed with the liquid crystal alignment direction control electrode formed in a lower layer of slits of the transparent pixel electrode via the insulated layer, and the transparent pixel electrode.

【Claim 20】

The vertically aligned mode liquid crystal display according to Claim 3,9,

wherein both of contact buttons of the scan signal wiring and the liquid crystal alignment direction control electrodes are arranged on either of left side or right side of a display screen part, and contact button parts of two rows of the liquid

crystal alignment direction control electrode for controlling one row of pixels are arranged so that they may be sandwiched between the contact button parts of the scan signal wiring.

【Claim 21】

The vertically aligned mode liquid crystal display according to Claim 5,11,

wherein both of contact button of the scan signal wiring and the liquid crystal alignment direction control electrodes are arranged on either of left side or right side of a display screen part, and contact button parts of one row of the liquid crystal alignment direction control electrode for controlling one row of pixels are arranged so that they may be sandwiched between the contact button of the scan signal wiring.

【Claim 22】

The vertically aligned mode liquid crystal display according to Claim 1, 3,5,7,9,11,

wherein contact button parts of the scan signal wiring are arranged on either of left side or right side of a display screen part, and contact button parts of the liquid crystal alignment direction control electrode are arranged on another side different from a side of the contact button parts of the scan signal wiring.

【Claim 23】

The vertically aligned mode liquid crystal display according to Claim 3,9,

wherein contact buttons for both of the scan signal wiring and the liquid crystal alignment direction control electrodes are arranged on both of right and left sides of a display screen part, and contact button parts of two rows of the liquid crystal alignment direction control electrode for controlling one row of pixels are arranged so that they may be sandwiched between the contact button parts of the scan signal wiring.

【Claim 24】

The vertically aligned mode liquid crystal display according to Claim 5,11,

wherein contact buttons for both of the scan signal wiring and the liquid crystal alignment direction control electrodes are arranged on both of right and left sides of a display screen part, and the contact button parts of one row of the liquid crystal alignment direction control electrode for controlling one row of pixels are arranged so that they may be

sandwiched between the contact button part of the scan signal wiring.

【Claim 25】

The vertically aligned mode liquid crystal display according to Claim 1, 3,5,7,9,11,

wherein at the time of moving image displaying, a bias voltage impressed between the liquid crystal alignment direction control electrode currently formed in a lower layer of a slit of the transparent pixel electrode and the transparent pixel electrode is set higher than a voltage at the time of still picture displaying, and thereby, a tilting speed of the anisotropic liquid crystal molecules having a negative dielectric constant are set higher.

【Detailed Description of the Invention】

【0001】

【Art Field of the Invention】

The present invention relates to a big screen active matrix type liquid crystal TV viewing display having a wide viewing angle, high brightness, and high speed of response by low cost, and to a driving method thereof.

【0002】

【Prior Art】

As shown in Fig. 1, in conventional type vertically aligned mode liquid crystal displays, a mode is adopted in which bumps for controlling a motion direction of liquid crystal molecules are formed on a transparent common electrode of a color filter side substrate, and slits for controlling a motion direction of the liquid crystal molecules are provided in transparent pixel electrodes of an active matrix substrate, the bumps and the slits determine the motion direction of the liquid crystal molecules serving as one set. There is also provided a method in which slits for controlling a motion direction of liquid crystal molecules in place of bumps are formed on a transparent common electrode on a color filter side substrate. Both of these modes are put in practical use for mass-production.

【0003】

【Problems to be Solved by the Invention】

In conventional type multi-domain vertically aligned mode liquid crystal displays, it has been necessary that bumps or slits are formed on a transparent common electrode in a color filter side substrate, which required one excessive photo mask

process. Therefore, cost rise became unavoidable.

【0004】

Moreover, in vertically aligned mode liquid crystal displays with bumps formed in color filter layer side, as shown in Fig. 1, when a width, a pitch, and an angle of slope of the bumps are not precisely controlled, variation in tilting degree of liquid crystal molecules will be caused, which easily generated unevenness in half tone area.

Since bumps are made of positive type photoresists, perfect removal of organic solvents, and furthermore hardening by baking at high temperatures of no less than 200 degrees are furthermore required, leading difficulty in shortening of processes. When contaminants are eluted out into liquid crystals from the bumps of positive type photoresists, a phenomenon of afterimage will occur, leading to problems in respect of reliability.

【0005】

In color filter substrates using conventional bumps, positive type photoresists are used as materials for bumps, and therefore, when a defect occurs in application process of a vertical alignment film and reworking is required, a dry ashing method using oxygen plasma can not be used. Therefore, a wet remove method requiring high running cost had to be used, which caused a defect requiring a very high reworking cost.

【0006】

In vertically aligned mode liquid crystal displays using conventional type bumps and slits, when a display switchovered to a half tone display from a black display, or to a half tone display from a white display, there has been defects that liquid crystals showed a slow response speed.

【0007】

The present invention solves the above-mentioned problems, and an object of the present invention is to improve reliability of a large-sized vertically aligned mode liquid crystal display and to realize a liquid crystal display that may be manufactured at low cost in a short time, and moreover that has high brightness and high-speed of response.

【0008】

【Means for Solving the Problems】

In order to solve the subject and to attain the above-mentioned purpose, following means are used in the present invention.

【0009】

[Means 1]

In order to impress a voltage to anisotropic liquid crystal molecules that are vertically aligned to an active matrix substrate and a color filter substrate and have a negative dielectric constant, and to make the liquid crystal molecules tilt in different two directions or four directions, two kinds of following electrode structures were formed in one pixel of the active matrix substrate.

i) A transparent flat common electrode is used in a color filter substrate side, and for transparent pixel electrodes countering the transparent flat common electrode in the active matrix substrate side, patterns (no transparent electrode in a slit part) having a shape of a long and slender slit are formed.

ii) a transparent flat common electrode is used in a color filter substrate side, and for transparent pixel electrodes countering the transparent flat common electrode in the active matrix substrate side, patterns having a shape of a long and slender slit are formed, two rows of liquid crystal alignment direction control electrodes that are mutually separated and set as potentials different from each other exist in a lower layer of the transparent pixel electrode via an insulated layer, either of the liquid crystal alignment direction control electrodes have almost the same shape as a shape of a pattern of the shape of long and slender slits, and a larger dimension than a dimension of the slit; and two rows of the liquid crystal alignment direction control electrodes mutually separated are arranged in a direction of a scan signal wire in a lower layer of the long and slender slits that are formed, mutually exchanged in an every fixed pixel cycle, in the transparent pixel electrode.

【0010】

[Means 2]

A following drive system is used as a method for driving the vertically aligned mode liquid crystal display having the electrode structure by the means 1.

There is used a drive system in which: when a potential of the transparent pixel electrode separated for every pixel of an active matrix substrate side is lower than a potential of the countering flat common electrode on a color filter substrate side, a potential of the liquid crystal alignment direction control electrode currently placed in a lower layer of the slit

of the transparent pixel electrode is set lower than a potential of the transparent pixel electrode; and when a potential of the transparent pixel electrode is higher than a potential of the countering flat common electrode of the color filter substrate side, a potential of the liquid crystal alignment direction control electrode placed in a lower layer of the slit of the transparent pixel electrode is set higher than a potential of the transparent pixel electrode, and potentials of the liquid crystal alignment direction control electrodes arranged in the vicinity of both sides of the scan signal wiring are set as polar potentials different from each other, and polarities of the potential of the transparent pixel electrode, and each of the potential of the two rows of the liquid crystal alignment direction control electrodes mutually separated in one pixel are reversed to a polarity of a polarity of the potential of the common electrode in a color filter substrate side every vertical scanning period.

【0011】

[Means 3]

In a color active matrix type vertically aligned mode liquid crystal display in which adjacent transparent pixel electrodes in a direction of a scan signal wiring are connected to a thin film transistor controlled by mutually different scan signal wirings, in order to impress a voltage to liquid crystal molecules that are vertically aligned between an active matrix substrate and a color filter substrate and to make the liquid crystal molecules tilt in different two directions or different four directions, two kinds of following electrode structures were formed in one pixel of the active matrix substrate.

i) A transparent flat common electrode is used in a color filter substrate side, and for transparent pixel electrodes countering the transparent flat common electrode in the active matrix substrate side, patterns (no transparent electrode in a slit part) having a shape of a long and slender slit are formed.

ii) A transparent flat common electrode is used in a color filter substrate side, and for transparent pixel electrodes countering the transparent flat common electrode in the active matrix substrate side, patterns having a shape of a long and slender slit are formed, and a liquid crystal alignment direction control electrode having almost the same shape as a shape of the slit, and a larger dimension than a dimension of

the slit are formed in a lower layer of the slit via an insulated film.

【0012】

[Means 4]

A following drive system is used as a method for driving the vertically aligned mode liquid crystal display having the electrode structure by the means 3.

There is used a drive system in which: when a potential of the transparent pixel electrode separated for every pixel of an active matrix substrate side is lower than a potential of the countering flat common electrode on a color filter substrate side, a potential of the liquid crystal alignment direction control electrode currently placed in a lower layer of the slit of the transparent pixel electrode is set lower than a potential of the transparent pixel electrode; and when a potential of the transparent pixel electrode is higher than a potential of the countering flat common electrode of the color filter substrate side, a potential of the liquid crystal alignment direction control electrode placed in a lower layer of the slit of the transparent pixel electrode is set higher than a potential of the transparent pixel electrode; and polarities of the potential of the transparent pixel electrode, and of the potential of the liquid crystal alignment direction control electrode are reversed to a polarity of a potential of the common electrode in a color filter substrate side every vertical scanning period.

【0013】

[Means 5]

In order to impress a voltage to anisotropic liquid crystal molecules that are vertically aligned to an active matrix substrate and a color filter substrate and have a negative dielectric constant, and to make the liquid crystal molecules tilt in many directions, two kinds of following electrode structures were formed in one pixel of the active matrix substrate.

i) A transparent flat electrode is used in a color filter substrate side, and for transparent pixel electrodes countering the transparent flat electrode on the active matrix substrate side, many circular or polygonal holes (no transparent electrodes in a portion of a hole) are formed.

ii) A transparent flat electrode is used in a color filter substrate side, and for transparent pixel electrodes

countering the transparent flat electrode in the active matrix substrate side, patterns having a shape of a long and slender slit are formed, two rows of liquid crystal alignment direction control electrodes that are mutually separated and set as potentials different from each other exist in a lower layer of the transparent pixel electrode via an insulated layer, either of the liquid crystal alignment direction control electrodes has almost the same shape as a shape of a pattern of the shape of long and slender slits, and a larger dimension than a dimension of the slit, and two rows of the liquid crystal alignment direction control electrodes mutually separated are arranged in a direction of a scan signal wiring in a lower layer of the long and slender slits that are formed, mutually exchanged in an every fixed pixel cycle, in the transparent pixel electrode.

【0014】

[Means 6]

A following drive system is used as a method for driving the vertically aligned mode liquid crystal display having the electrode structure by the means 5.

There is used a drive system in which: when a potential of the transparent pixel electrode separated for every pixel of an active matrix substrate side is lower than a potential of the countering flat common electrode on a color filter substrate side, a potential of the liquid crystal alignment direction control electrode currently placed in a lower layer of a slit of the transparent pixel electrode is set lower than a potential of the transparent pixel electrode; and when a potential of the transparent pixel electrode is higher than a potential of the countering flat common electrode of the color filter substrate side, a potential of the liquid crystal alignment direction control electrode placed in a lower layer of the slit of the transparent pixel electrode is set higher than a potential of the transparent pixel electrode; and potentials of the liquid crystal alignment direction control electrodes arranged in the vicinity of both sides of the scan signal wiring are set as polar potentials different from each other, and polarities of the potential of the transparent pixel electrode, and of each of the potential of the two rows of the liquid crystal alignment direction control electrodes mutually separated in one pixel are reversed to a polarity of a potential of the common electrode in a color filter substrate side every vertical scanning period.

【0015】

[Means 7]

In an active matrix type vertically aligned mode liquid crystal display in which adjacent transparent pixel electrodes in a direction of a scan signal wiring are connected to a thin film transistor component controlled by mutually different scan signal wirings, in order to impress a voltage to liquid crystal molecules that are vertically aligned between an active matrix substrate and a color filter substrate and to make the liquid crystal molecules tilt in many directions, two kinds of following electrode structures were formed in one pixel of the active matrix substrate.

i) A transparent flat electrode is used in a color filter substrate side, and for transparent pixel electrodes countering the transparent flat electrode in the active matrix substrate side, many circular or polygonal holes (no transparent electrodes in a portion of a hole) are formed.

ii) A transparent flat electrode is used in a color filter substrate side, and for transparent pixel electrodes countering the transparent flat electrode in the active matrix substrate side, patterns having a shape of a long and slender slit are formed, a liquid crystal alignment direction control electrode having almost the same shape as a shape of the slit, and a larger dimension than a dimension of the slit are formed in a lower layer of the slit via an insulated film.

【0016】

[Means 8]

A following drive system is used as a method for driving the vertically aligned mode liquid crystal display having the electrode structure by the means 7.

There is used a drive system in which: when a potential of the transparent pixel electrode separated for every pixel on an active matrix substrate side is lower than a potential of the countering flat common electrode on a color filter substrate side, a potential of the liquid crystal alignment direction control electrode currently placed in a lower layer of a slit of the transparent pixel electrode is set lower than a potential of the transparent pixel electrode; and when a potential of the transparent pixel electrode is higher than a potential of the countering flat common electrode of the color filter substrate side, a potential of the liquid crystal alignment direction control electrode placed in a lower layer of the slit of the

transparent pixel electrode is set higher than a potential of the transparent pixel electrode; and polarities of the potential of the transparent pixel electrode, and of the potential of the liquid crystal alignment direction control electrode are reversed to a polarity of a potential of the common electrode in a color filter substrate side every vertical scanning period.

【0017】

[Means 9]

In the means 1, 3, the slit formed in the transparent pixel electrode in an active matrix substrate side and extending long and slender, and the slit forming a group with the liquid crystal alignment direction control electrode are arranged alternately, maintaining an almost parallel relationship in a direction making about ± 45 degrees to a direction of the scan signal wiring; and polarization axes of two polarizing plates placed in exterior of a liquid crystal cell are arranged in a direction of the scan signal wiring and in a direction of the video signal wiring, and are arranged so that they may perpendicularly mutually intersect.

【0018】

[Means 10]

In the means 1, 3, there was adopted a structure that the slit formed in the transparent pixel electrode in an active matrix substrate side and extending long and slender is arranged in a direction making ± 45 degrees to a direction of a scan signal wiring; and the slit forming a group with the liquid crystal alignment direction control electrode are arranged in a parallel direction and in a perpendicular direction to a direction of the scan signal wirings; and the liquid crystal alignment direction control electrode encloses a periphery of the pixel electrode while overlapping with the pixel electrode via the insulated film; and polarization axes of two polarizing plates placed in exterior of a liquid crystal cell are arranged in the direction of the scan signal wiring and in a direction of the video signal wiring, and are arranged so that they may perpendicularly mutually intersect.

【0019】

[Means 11]

In the means 1, 3, there was adopted a structure that the slit formed in a transparent pixel electrode in an active matrix substrate side and extending long and slender is

arranged in a parallel direction and in a perpendicular direction to the direction of the scan signal wiring; and the slit forming a group with the liquid crystal alignment direction control electrode is arranged in parallel to a direction of the scan signal wiring; and the liquid crystal alignment direction control electrode encloses a periphery of the pixel electrode while overlapping with the pixel electrode via the insulated film; and polarization axes of two polarizing plates placed in exterior of a liquid crystal cell are arranged a direction of the scan signal wiring and in a direction of the video signal wiring, and are arranged so that they may perpendicularly mutually intersect.

【0020】

[Means 12]

In the means 1, 3, the slit formed in a transparent pixel electrode in an active matrix substrate side and extending long and slender is arranged in a parallel direction and in a perpendicular direction to a direction of the scan signal wiring; and the slit forming a group with the liquid crystal alignment direction control electrode have a structure arranged in directions making ± 45 degrees to a direction of the scan signal wiring; and polarization axes of two polarizing plates placed in exterior of a liquid crystal cell are arranged in a direction of the scan signal wiring and in a direction of the video signal wiring, and are arranged so that they may perpendicularly mutually intersect.

【0021】

[Means 13]

In the means 5,7, there was adopted a structure that the slit forming a group with the liquid crystal alignment direction control electrode are arranged in a parallel direction and in a perpendicular direction to a direction of the scan signal wiring so as to enclose two or more of circular or polygonal holes currently formed in the transparent pixel electrode in an active matrix substrate side; and the liquid crystal alignment direction control electrode encloses a periphery of the pixel electrode while overlapping with the pixel electrode via the insulated film; and polarization axes of two polarizing plates placed in exterior of a liquid crystal cell are arranged in a direction of the scan signal wiring and in a direction of the video signal wiring, and are arranged so that they may perpendicularly mutually intersect.

【0022】

[Means 14]

In the means 1,3,5,7, the liquid crystal alignment direction control electrode formed in a lower layer of the slit of the transparent pixel electrode via the insulated layer is simultaneously formed in the same layer at the time of formation of the scan signal wiring.

【0023】

[Means 15]

In the means 1, 3, 5, 7, an additional capacitance was formed with the liquid crystal alignment direction control electrode formed in a lower layer of the slit of the transparent pixel electrode via the insulated layer, and the transparent pixel electrode.

【0024】

[Means 16]

In the means 1, 5, all of the scan signal wirings and the liquid crystal alignment direction control electrodes are completely separated, and are connected to output terminals of different drive ICs, respectively; and contact button parts of the two rows of liquid crystal alignment direction control electrodes for controlling one row of pixels are arranged so that they may be sandwiched between contact button parts of different scan signal wirings.

【0025】

[Means 17]

In the means 3, 7, all of the scan signal wirings and the liquid crystal alignment direction control electrodes are completely separated and independent, and are connected to output terminals of different drive ICs, respectively; and contact button parts of the one row of liquid crystal alignment direction control electrodes for controlling one row of pixels are arranged so that they may be sandwiched between contact button parts of different scan signal wirings.

【0026】

[Means 18]

In the means 1, 3, 5,7, contact button parts of the scan signal wiring are arranged in either of right side or left side of a display screen part, and contact button parts of the liquid crystal alignment direction control electrode are arranged on another side different from a side of contact button parts of the scan signal wiring, each contact button is mutually

completely separated and independent, and is connected to output terminals of different drive ICs, respectively.

【0027】

[Means 19]

In the means 1, 5, the scan signal wirings and the liquid crystal alignment direction control electrodes are completely separated and independent, each contact button is arranged on both of right and left sides of a display screen part, and contact button parts of the two rows of the liquid crystal alignment direction control electrodes for controlling one row of pixels are arranged so that they may be sandwiched between contact button parts of different scan signal wirings.

【0028】

[Means 20]

In the means 3,7, all of scan signal wirings and liquid crystal alignment direction control electrodes are completely separated and independent, each contact button is arranged on both of right and left sides of a display screen part, and contact button parts of the one row of liquid crystal alignment direction control electrodes for controlling one row of pixels are arranged so that they may be sandwiched between contact button parts of different scan signal wirings.

【0029】

[Means 21]

In the means 2, 4, 6, 8, at the time of moving image displaying, a bias voltage impressed between the liquid crystal alignment direction control electrode currently formed in a lower layer of the slit of the transparent pixel electrode and the transparent pixel electrode is set higher than a voltage at the time of still picture displaying, and thereby, a tilting speed of anisotropic liquid crystal molecules having a negative dielectric constant are set higher.

【0030】

【Operations】

Use of the means 1, 2, 3, 4, 5, 6, 7, 8, enables anisotropic liquid crystal molecules having a negative dielectric constant in a state of being vertically aligned to tilt in a target direction, as shown in Fig. 2, Fig. 3, Fig. 5, Fig. 6.

This makes unnecessary formation of a bump⑤ that had to be formed on a color filter side substrate of a vertically aligned mode liquid crystal display, for motion directional control of liquid crystal molecules, as is shown in conventional method

Fig. 1. Moreover, this enables manufacture of a multi-domain vertically aligned mode liquid crystal display using a cheap color filter, as shown in Fig. 4.

Furthermore, only alignment layers and anisotropic liquid crystal molecules having a negative dielectric constant exist between a flat common electrode in a color filter side, and a transparent pixel electrode of an active matrix substrate as shown in Fig. 4, which completely solves problems, such as diffusion of contaminants from the bump ⑤, and remarkably improves reliability.

【0031】

Additionally, even in case of failure in application of an alignment layer, omission of bump ⑤ enables simple and short time regeneration with oxygen plasma by a dry-asher. That is, in surface treatment process before alignment layer application, a plasma treatment with oxygen and argon using a dry-asher becomes usable, which remarkably decrease repelling and generation of pinhole in alignment layer application process.

【0032】

Use of the means 9, 10, 11, 12, 13 may sharply improve effective use efficiency of polarizing plates, and thereby may reduce a cost of polarizing plates used for very large-sized liquid crystal displays. Effective use efficiency of a polarizer having reflexibility comprising multilayer laminated body of two kinds of materials used for a backlight may also be sharply improved, which may also reduce cost of a backlight for very large-sized liquid crystals display. Moreover, possibility of control for a motion direction of liquid crystal molecules in four directions may provide wide viewing angles.

【0033】

Use of the means 14 ,15 enables manufacture of an active matrix substrate of the present invention using completely same processes, without changing manufacturing processes of conventional active matrix substrate.

In addition, since a liquid crystal alignment direction control electrode is arranged close to both sides of a video signal wiring and, as shown in Fig. 7, Fig. 8, Fig. 9, Fig. 10, Fig. 14, Fig. 16, Fig. 17, Fig. 18, Fig. 25, a potential variation of a video signal wiring is easily shielded, which may completely control a cross talk generation in a

perpendicular direction.

【0030】

Use of the means 16, 17, 18, 19, 20 enables separate drive for every row of liquid crystal alignment direction control electrodes currently formed in a lower layer of slits of transparent pixel electrodes of each row, enabling uniform display by same conditions in all portions of upper part, central part, and lower part of a display screen.

【0031】

Use of the means 2, 4, 6, 8, 21 enables anisotropic liquid crystal molecules having a negative dielectric constant in a state of being vertically aligned to tilt in a target direction, preventing generation of disclination to enable uniform half tone display. Additionally, use of the method of the present invention may sharply improve a late response speed, in a change to a half tone display from a black display, and to a half tone display from a white display, that has been a problem in a conventional vertically aligned mode liquid crystal display mode. In case of responding animated pictures, increase of a bias voltage impressed between a certain transparent pixel electrode and a liquid crystal alignment direction control electrode formed in a lower layer of slits of the transparent pixel electrode may further improve a speed of response. In the present invention, since a display approaches closer to black display and the above-mentioned bias voltage may become larger, a speed of response is improvable in all regions.

【0032】

【Embodiments of the Invention】

[Embodiment 1]

Figs. 4, 5,6 show sectional views of Embodiment 1 of the present invention. A color filter substrate has a flat transparent common electrode, and an active matrix substrate is arranged facing the substrate and in parallel.

In the active matrix substrate, firstly, a scan signal wiring and a liquid crystal alignment direction control electrode are simultaneously formed in the same layer, and subsequently, a gate insulator film, an amorphous silicone layer, and an n^+ amorphous silicone layer for ohmic contacts are deposited.

After formation of a thin film transistor element part, a video signal wiring and a drain electrode are formed.

Next, a contact hole is formed in a portion of a drain

electrode after deposition of a passivation film, and then a transparent electric conductive film is deposited. In the transparent electric conductive film, as shown in Fig. 7, some slits are formed and each pixel is completely separated for every pixel to provide a transparent pixel electrode.

An electrode structure of the present invention has following special features: there exist one another in one pixel a portion in which a long and slender slit, or a circular or polygonal hole is formed facing a flat common electrode on a color filter side, as shown in Fig. 2; and a portion in which a long and slender slit and a liquid crystal alignment direction control electrode in the lower layer of the slits, having almost the same shape as the slit, and having a larger dimension than a dimension of the slit are formed facing the flat common electrode on a color filter side, as shown in Fig. 3.

As shown in Fig. 5, Fig. 6, these two kinds of electrode structures control to tilt correctly anisotropic liquid crystal molecules having a negative dielectric constant in two directions, four directions, or many directions, that is, in target directions within one pixel. Distribution of equipotential lines is shown in Fig. 2, Fig. 3.

【0033】

As shown in Fig. 4, Fig. 5, Fig. 6, in Embodiment 1, liquid crystal alignment direction control electrodes are arranged close to both of right and left sides of a video signal wiring. Since the liquid crystal alignment direction control electrode shields a signal voltage variation of the video signal wiring, effect of the video signal wiring is not transmitted to the transparent pixel electrode. As compared with conventional vertically aligned mode liquid crystal displays shown in Fig. 1, a vertically aligned mode liquid crystal display of the present invention of Fig. 4 generates very little perpendicular cross talk. Since a width of BM (shading film) of a color filter may also be set more narrowly than in conventional products, a vertically aligned mode liquid crystal display with a large aperture ratio may be realizable.

【0034】

[Embodiment 2]

Fig. 30, Fig. 31, Fig. 32 show sectional views of Embodiment 2 of the present invention. In fundamental aspect, almost the same structure as in Embodiment 1 is used for Embodiment 2. An electrode structure of the Embodiment has

special features that two kinds of electrode structures as shown in Fig. 2, Fig. 3 exist together in one pixel.

As shown in Fig. 30, Fig. 31,Fig. 32, since a video signal wiring is only sandwiched by pixel electrodes from both of right and left sides, capacitance of a video signal wiring can be designed minimal, and accordingly, even if a resistance of the video signal wiring is high, a problem of signal delay is hard to be generated.

Fig. 24 shows a plan view of Embodiment 2. Only one row of liquid crystal alignment direction control electrode exists in one pixel. Adjacent pixel electrodes are connected to a thin film transistor controlled by a different scan signal wiring, respectively.

As a plan view of Fig. 24 shows, since an area in which the liquid crystal alignment direction control electrode exists close to a scan signal wiring is small, even if the scan signal wiring and the liquid crystal alignment direction control electrode are simultaneously formed in the same layer, a probability that a defect in which electric short-circuit is provided by a connection of each other will occur is extremely small.

Slits are formed in a direction parallel direction and a perpendicular direction to the scan signal wiring, and slits forming a group with a liquid crystal alignment direction control electrode are extended in angle directions of ± 45 degrees to the scan signal wiring direction. Slits forming a group with a liquid crystal alignment direction control electrode may have a form like connected diamond-shapes, and may have a form like squares located in a line as shown in Fig. 28, Fig. 29.

【0035】

[Embodiment 3]

Fig. 7 shows a plan view of Embodiment 3 of the present invention. The Embodiment has a structure where two kinds of structures, a structure shown in a cross section structural figure of Embodiment 1 and a structure shown in a cross section structural figure of Embodiment 2, are mixed inside one pixel. In one pixel, two rows of liquid crystal alignment direction control electrodes are arranged, each potential is set as positive electrode potential and negative electrode potential on the basis of a potential of a countering common electrode of a color filter side substrate. Adjacent transparent pixel

electrodes are controlled by a different liquid crystal alignment direction control electrode, respectively.

As shown in Fig. 11, Fig. 12, when a signal having a positive polarity is written in a transparent pixel electrode, a potential of a liquid crystal alignment direction control electrode currently formed via an insulator film in a lower layer of a slit of the transparent pixel electrode has a positive polar potential higher than a potential of the transparent pixel electrode, and when a signal having a negative polarity is written in the transparent pixel electrode, a potential of a liquid crystal alignment direction control electrode currently formed via an insulator film in a lower layer of a slit of the transparent pixel electrode has a negative polar potential lower than a potential of the transparent pixel electrode.

Transparent pixel electrode, and liquid crystal alignment direction control electrodes of two rows arranged in one pixel have exchanged polarity, respectively, every perpendicular period.

【0036】

As shown in Fig. 7, slits currently formed in a transparent pixel electrode and liquid crystal alignment direction control electrodes arranged in a lower layer of the slit are arranged so as to make angles of ± 45 degrees to a direction of a scan signal wiring.

In an upper half and a lower half in one pixel, the slit and the liquid crystal alignment direction control electrodes of a lower layer of the slit, respectively, are arranged alternately and almost in parallel each other. Special feature is that a liquid crystal alignment direction control electrode is arranged in a central part of the pixel so as to divide the upper half and the lower half. Polarizing plates are arranged so that polarization axes may become parallel and perpendicular to the scan signal wiring and may have a relationship of intersecting mutually perpendicular, in an exterior of the liquid crystal cell.

【0037】

[Embodiment 4]

Fig. 8, Fig. 9, Fig. 10 show a plan view of Embodiment 4 of the present invention. This Embodiment adopts a cross section structural figure of Embodiment 1, and liquid crystal alignment direction control electrodes enclose periphery of a

transparent pixel electrode, which makes it difficult that the transparent pixel electrode is influenced by a potential variation of a video signal wiring, and thus hardly generates a perpendicular cross talk. Moreover, since liquid crystal alignment direction control electrodes and the transparent pixel electrode are overlapped, a width of a shading film of a color filter (BM) may be narrowed, and an aperture ratio may be increased.

In addition, liquid crystal alignment direction control electrodes of two rows exist in one pixel, and thereby almost the same system as the drive system in Embodiment 3 may be used.

In Fig. 8, slits formed in the pixel electrode are arranged in directions of ± 45 degrees to a direction of the scan signal wirings. In Fig. 9, slits formed in the pixel electrode are arranged in two directions perpendicular and horizontal to a direction of the scan signal wirings. In Fig. 10, fine notches of slit are formed in motion directions of liquid crystal molecules in the pixel electrode. Arrangement of polarizing plates may be completely the same arrangement as an arrangement in Embodiment 3.

【0038】

[Embodiment 5]

Fig. 14 shows a plan view of Embodiment 5 of the present invention. This Embodiment adopts a cross section structural figure of Embodiment 1, and liquid crystal alignment direction control electrodes enclose periphery of a transparent pixel electrode, which makes it difficult that the transparent pixel electrode is influenced by a potential variation of a video signal wiring, and thus hardly generates a perpendicular cross talk. This Embodiment differs from Embodiment 4 in a point that many circular holes are formed in the transparent pixel electrode. As long as they are holes, polygonal forms may be of any kinds other than a circular form. Liquid crystal alignment direction control electrodes of two rows exist in one pixel, and the same drive system as in Embodiment 3 may be used. Arrangement of polarizing plates may be the same arrangement as an arrangement in Embodiment 3.

【0039】

[Embodiment 6]

Fig. 16 shows a plan view of Embodiment 6 of the present invention. This Embodiment has a structure where two kinds, a cross section structural figure of Embodiment 1 and a cross

section structural figure of Embodiment 2, are mixed inside one pixel. A liquid crystal alignment direction control electrode of one row is arranged in one pixel, and adjacent pixel electrodes are connected, respectively, with a thin film transistor element currently controlled by a different scan signal wiring. Forms of a long and slender slit currently formed in transparent pixel electrode and of the liquid crystal alignment direction control electrode currently formed in a lower layer of the slit via an insulator film are almost the same as in Embodiment 3, and are arranged to make angles of ± 45 degrees to the direction of scan signal wiring.

In an upper half and a lower half in one pixel, the slit and the liquid crystal alignment direction control electrode formed in a lower layer of the slit, respectively, are arranged alternately and almost in parallel each other. A liquid crystal control electrode is arranged that divides an upper half and a lower half in a central part of a pixel. Polarizing plates are arranged so that polarization axes may become parallel and perpendicular to the scan signal wiring and may have a relationship of intersecting mutually perpendicular, in an exterior of the liquid crystal cell.

【0040】

In all Embodiments of the present invention, a transparent pixel electrode, and liquid crystal alignment direction control electrodes overlap mutually via the insulator film, and form an additional capacity (storage capacitor). When a larger additional capacity is required, an overlapping area may be set larger. When a smaller additional capacity is required, an overlapping area may be set smaller. In an usual range, an overlapping width of about 2 micron provides a sufficient additional capacity.

【0041】

Fig. 22, Fig. 23 show a driving method of Embodiment 6. A driving method of the Embodiment differs from a driving method of Embodiment 3 a little.

In Embodiment 3, there is used a method that adjacent pixel electrodes are controlled by the same scan signal wiring in Embodiment 3, and video signals having different polarity, respectively, are written in from a video signal wiring. In Embodiment 6, there is used a method that adjacent pixel electrodes are controlled by a different scan signal wiring, and video signals having the same polarity are written in after

a shift of one horizontal scanning-period from a video signal wiring. As Fig. 22, Fig. 23 show, when a positive signal is written in a transparent pixel electrode, a potential of a liquid crystal alignment direction control electrode has a positive polar potential higher than the transparent pixel electrode, and when a negative signal is written in the transparent pixel electrode, a potential of the liquid crystal alignment direction control electrode has a negative polar potential lower than the transparent pixel electrode. The transparent pixel electrode and the liquid crystal alignment direction control electrode reverse each polarity for every perpendicular period.

【0042】

In all Embodiments of the present invention, it is possible to tilt molecules of anisotropic liquid crystal having a negative dielectric constant in a target direction from a perpendicular direction by setting a potential difference between a transparent pixel electrode and liquid crystal alignment direction control electrodes. In this case tilt angle may only be one - two degrees from a perpendicular direction (90 degrees). Usually, a bias potential of no less than 4 - 5 V is impressed. When a high-speed response is required, it is necessary to set a tilt angle as no less than 10 degrees, and a bias potential of no less than 6 - 8 V is impressed in this case. When the present invention is used for a liquid crystal TV, it is effective to set a bias potential between a transparent pixel electrode and liquid crystal alignment direction control electrodes larger. When the present invention is made to serve a double purpose for a viewing display for computers, and for a moving image displaying apparatus for TV, it is effective to perform a circuit design so that this bias potential may be variable.

【0043】

[Embodiment 7]

Fig. 17, Fig. 18 show plan view of Embodiment 7 of the present invention. This Embodiment adopts a cross section structural figure of Embodiment 1, a liquid crystal alignment direction control electrode encloses a periphery of a transparent pixel electrode, which makes it difficult that the transparent pixel electrode is influenced by a potential variation of a video signal wiring, and hardly generates a perpendicular cross talk. One row of liquid crystal alignment

direction control electrode exists in one pixel, and adjacent transparent pixel electrodes are connected to a thin film transistor element controlled by a different scan signal wiring, respectively. A driving method of this Embodiment is same as in Embodiment 6. Arrangement of polarizing plate is also same as in Embodiment 6.

【0044】

[Embodiment 8]

Fig. 25 shows a plan view of Embodiment 8 of the present invention. This Embodiment adopts a cross section structural figure of Embodiment 1, and a liquid crystal alignment direction control electrode encloses a periphery of a transparent pixel electrode, which makes it difficult that the transparent pixel electrode is influenced by a potential variation of a video signal wiring, and hardly generates a perpendicular cross talk. One row of liquid crystal alignment direction control electrode exists in one pixel, and adjacent transparent pixel electrodes are connected to a thin film transistor element controlled by a different scan signal wiring, respectively. A driving method of this Embodiment is same as in Embodiment 6. Many circular holes are formed in the transparent pixel electrode. As long as they are holes, polygonal forms may be of any kinds other than a circular form. A rotatory polarization liquid crystal display mode may be realizable by blending one of chiral material of left-handed rotation or right-handed rotation to an anisotropic liquid crystal having a negative dielectric constant. In this case, a value of product of a liquid crystal cell gap d and a refractive index anisotropy Δ n should just be in a range of 0.30 - 0.60 micrometer. Molecules of anisotropic liquid crystal having a negative dielectric constant tilt aligning in a shape of a swirl, while performing a left slewing motion or a right slewing motion centering on a circular hole, can pass a light from a backlight from perpendicularly arranged polarizing plates.

【0045】

[Embodiment 9]

Fig. 20 shows a plan view of active matrix substrate of Embodiment 9 of the present invention. Both of contact button parts of scan signal wiring and a liquid crystal alignment direction control electrode are gathered a in left side of a display screen. Fig. 19 shows an expansion plan view of the

contact button part.

Fig. 13 shows an expansion plan view of a contact button part in the case where liquid crystal alignment direction control electrodes of two rows exist in one pixel.

One scan signal wiring is sandwiched from both of upper side and lower side by liquid crystal alignment direction control electrodes of different rows. Polarity switching of upper-side and lower-side liquid crystal alignment direction control electrodes is simultaneously performed based on a timing as shown in Fig. 33, and thereby a potential variation of the scan signal wiring may be controlled minimal, which suppresses generation of horizontal periodic unevenness in a display screen. As Fig. 13 show, a short-circuit between buttons may be prevented by providing a distance between the buttons of the scan signal wiring, and the contact buttons of the liquid crystal alignment direction control electrode.

【0046】

[Embodiment 10] Fig. 15,Fig. 21 show a plan view of an active matrix substrate of Embodiment 10 of the present invention. Contact button part of a scan signal wiring and contact button part of a liquid crystal alignment direction control electrode are separately divided into left side and right side of a display screen, respectively. A driving method of this Embodiment may be methods as shown in Fig. 11, Fig. 12, and may be a method as shown in Fig. 33. In Embodiment of the present invention, since a distance between contact buttons is expandable by adopting Fig. 15, Fig. 21, a short-circuit between contact buttons can be prevented. Furthermore, usual scan signal wiring drive IC in TN mode may be used, which enable cost reduction in development and production.

【0047】

[Embodiment 11]

Fig. 26, Fig. 27 show a plan view of an active matrix substrate of Embodiment 11 of the present invention. Each of contact botton part of a scan signal wiring and a liquid crystal alignment direction control electrode are provided in both of right and left ends of a display screen, which may solve easily a problem of delay of scan signal waveform, a largest problem when driving a large-sized liquid crystal display.

【0048】

【Effects of the Invention】

Use of the present invention does not require use of color

filter substrates with bumps or slits that have been used for conventional multi-domain vertically aligned mode liquid crystal displays, but enables reduction of cost.

In addition, it may also cancel simultaneously display unevenness induced by variation accompanying bumps or processing of slits, and extremely improves yield.

Furthermore, it suppresses problems of diffusion of impurities from crevices of bumps or slits, and thereby realizes extremely reliable vertically aligned mode liquid crystal displays.

Since possibility of reworking may easily be realized with oxygen plasma treatment irrespective of defects generation in a polyimide alignment layer application process, reduction of reworking costs may be realized.

【0049】

Since use of electrode structures and driving methods of the present invention may enable improvement of a speed of response of liquid crystal molecules, very large-sized liquid crystal TVs responding animated pictures may be realized.

【Brief Description of the Drawings】

【Fig. 1】

Fig. 1 shows a cross section structural figure of a conventional multi-domain vertically aligned mode liquid crystal panel;

【Fig. 2】

Fig. 2 shows a motion direction of molecules of anisotropic liquid crystal having a negative dielectric constant vertically aligned by an electric field formed with a flat electrode and a slit electrode;

【Fig. 3】

Fig. 3 shows a motion direction of molecules of anisotropic liquid crystal having a negative dielectric constant vertically aligned by an electric field formed with a flat electrode, a slit electrode, and liquid crystal alignment direction control electrode;

【Fig. 4】

Fig. 4 shows a cross section structural figure of a multi-domain vertically aligned mode liquid crystal panel of the present invention;

【Fig. 5】

Fig. 5 shows a drive principle cross section structural figure of a multi-domain vertically aligned mode liquid

crystal panel of the present invention (when a pixel electrode has a negative data);

【Fig. 6】

Fig. 6 shows a drive principle cross section structural figure of a multi-domain vertically aligned mode liquid crystal panel of the present invention (when a pixel electrode has a positive data);

【Fig. 7】

Fig. 7 shows a plane structural figure of a multi-domain vertically aligned mode liquid crystal panel of the present invention;

【Fig. 8】

Fig. 8 shows a plane structural figure of a multi-domain vertically aligned mode liquid crystal panel of the present invention;

【Fig. 9】

Fig. 9 shows a plane structural figure of a multi-domain vertically aligned mode liquid crystal panel of the present invention;

【Fig. 10】

Fig. 10 shows a plane structural figure of a multi-domain vertically aligned mode liquid crystal panel of the present invention;

【Fig. 11】

Fig. 11 shows a waveform chart of a voltage impressed to a thin film transistor of an odd number column of (n)th row and (n+1)th row of a multi-domain vertically aligned mode liquid crystal panel of the present invention;

【Fig. 12】

Fig. 12 shows a waveform chart of a voltage impressed to a thin film transistor of an even number column of (n)th row and (n+1)th row of a multi-domain vertically aligned mode liquid crystal panel of the present invention;

【Fig. 13】

Fig. 13 shows a plan view of contact button parts of scanning lines and liquid crystal alignment direction control electrodes of a multi-domain vertically aligned mode liquid crystal panel of the present invention;

【Fig. 14】

Fig. 14 shows a plane structural figure of a vertically aligned mode liquid crystal panel of the present invention;

【Fig. 15】

Fig. 15 shows a plan view of a vertically aligned mode active matrix substrate of the present invention;

【Fig. 16】

Fig. 16 shows a plane structural figure of a multi-domain vertically aligned mode liquid crystal panel of the present invention;

【Fig. 17】

Fig. 17 shows a plane structural figure of a multi-domain vertically aligned mode liquid crystal panel of the present invention;

【Fig. 18】

Fig. 18 shows a plane structural figure of a multi-domain vertically aligned mode liquid crystal panel of the present invention;

【Fig. 19】

Fig. 19 shows a plan view of contact button parts of scanning lines and liquid crystal alignment direction control electrodes of a multi-domain vertically aligned mode liquid crystal panel of the present invention;

【Fig. 20】

Fig. 20 shows a plan view of a vertically aligned mode active matrix substrate of the present invention;

【Fig. 21】

Fig. 21 shows a plan view of a vertically aligned mode active matrix substrate of the present invention;

【Fig. 22】

Fig. 22 shows a waveform of a voltage impressed to a transistor corresponding to a pixel of an odd number column of (n)th row and of (n+1)th row of a multi-domain vertically aligned mode liquid crystal panel of the present invention;

【Fig. 23】

Fig. 23 shows a waveform of a voltage impressed to a transistor corresponding to a pixel of an even number column of (n)th row and of (n+1)th row of a multi-domain vertically aligned mode liquid crystal panel of the present invention;

【Fig. 24】

Fig. 24 shows a plane structural figure of a multi-domain vertically aligned mode liquid crystal panel of the present invention;

【Fig. 25】

Fig. 25 shows a plane structural figure of a multi-domain vertically aligned mode liquid crystal panel of the present

invention;

【Fig. 26】

Fig. 26 shows a plan view of a vertically aligned mode active matrix substrate of the present invention;

【Fig. 27】

Fig. 27 shows a plan view of a vertically aligned mode active matrix substrate of the present invention;

【Fig. 28】

Fig. 28 shows a plan view and a cross section structural figure of slits formed in a liquid crystal alignment control electrode and a transparent pixel electrode of the present invention;

【Fig. 29】

Fig. 29 shows a plan view and a cross section structural figure of slits formed in a liquid crystal alignment direction control electrode and a transparent pixel electrode of the present invention;

【Fig. 30】

Fig. 30 shows a cross section structural figure of a multi-domain vertically aligned mode liquid crystal panel of the present invention;

【Fig. 31】

Fig. 31 shows a drive principle cross section structural figure of a multi-domain vertically aligned mode liquid crystal panel of the present invention (when a pixel electrode has a negative data);

【Fig. 32】

Fig. 32 shows a drive principle cross section structural figure of a multi-domain vertically aligned mode liquid crystal panel of the present invention (when pixel electrode has a positive data);

【Fig. 33】

Fig. 33 shows a waveform chart of a voltage impressed to a thin film transistor element of an odd number column (n)th row, and (n+1)th row of a multi-domain vertically aligned mode liquid crystal panel of the present invention;

【Description of Reference Numerals】

1 Color filter side glass substrate.

2 Black mask (shading film).

3 Color filter layer.

4 Color filter side transparent electric conductive film (transparent common electrode).

5 Bump for directional control of vertically aligned liquid crystal molecule.

6 Color filter side vertical alignment film.

7 Active matrix substrate side vertical alignment film.

8 Transparent pixel electrode.

9 Slit opening formed in pixel electrode side.

10 Passivation film.

11 Video signal wiring.

12 Gate insulator film.

13 Active matrix element side glass substrate.

14 Anisotropic liquid crystal molecules having a negative dielectric constant.

15 Liquid crystal alignment control electrode.

16 Thin film transistor element.

17 Scanning line.

18 Contact through hole.

19 Upper liquid crystal alignment direction control electrode.

20 Lower liquid crystal alignment direction control electrode.

21 Transparent common electrode potential.

22 Odd number column video signal wiring waveform.

23 Scanning line signal wave type of n row.

24 Scanning line signal wave type of (n+1) row.

25 Upper liquid crystal alignment direction control electrode signal waveform of n row.

26 Lower liquid crystal alignment direction control electrode signal waveform of n row.

27 Upper liquid crystal alignment direction control electrode signal waveform of (n+1) row.

28 Lower liquid crystal alignment direction control electrode signal waveform of (n+1) row.

29 Even number column video signal wiring waveform.

30 Scanning line contact button of (n-1) row.

31 Upper liquid crystal alignment direction control electrode contact button n row.

32 Lower liquid crystal alignment direction control electrode contact button of n row.

33 Scanning line contact button of n row.

34 Upper liquid crystal alignment direction control electrode contact button of (n+1) row.

35 Lower liquid crystal alignment direction control electrode contact button of (n+1) row.

36 Scanning line contact button of (n+1) row.

37 Hole opening formed in pixel electrode side.

38 Liquid crystal alignment control electrode contact button of (n-1) row.

39 Liquid crystal alignment control electrode contact button n row.

40 Video signal wiring terminal.

41 Pixel circumference common electrode terminal.

42 Protection network for static electricity measure.

43 Scanning line signal waveform of (n-1) row.

44 Liquid crystal alignment direction control electrode signal waveform of n row.

45 Liquid crystal alignment direction control electrode signal waveform of (n+1) row.